REVIEW OF SOIL INSECTS IN ONTARIO 1900 - 1973

Ontario Pesticides
Advisory Committee

March 26, 1974

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SOIL INSECTS IN ONTARIO 1900-1973

In 1969, aldrin, dieldrin and heptachlor were banned from agricultural use in Ontario. Prior to that they had been used extensively for soil insect control. At the time these insecticides were banned it was concluded that other insecticides were available to provide control of soil insects. It is now appropriate to review the status of soil insects in Ontario to learn whether or not significant population changes have occurred because aldrin, dieldrin and heptachlor are no longer being used. The Pesticides Advisory Committee therefore, conducted a study to determine the trends in populations of our major soil insect pests over the past years through a review of the literature that reports insect populations on a seasonal basis. Most of the records before 1940 have been taken from the Annual Report (Proceedings) of the Entomological Society of Ontario. These reports have been supplemented by the Research Report of the Canada Committee on Pesticide Use in Agriculture, reports in the Journal of Economic Entomology, the Canadian Insect Pest Review and by private communication with Canadian entomologists. These records, especially the earlier ones, are general in nature and tend to report insects on a comparative rating with other seasons. Thus, trends are indicated.

In this study the literature pertinent to Ontario was searched with respect to eleven categories of soil insects. In some cases, e.g., cutworms, several species of insects are grouped together while in other instances, e.g., northern corn rootworm,

only a specific insect is considered. The following insects were included:

1. Cabbage maggot
2. Onion maggot
3. Seed-corn maggot
4. Carrot rust fly
5. Northern corn rootworm
6. White grubs
7. Wireworms
8. Flea beetles
9. Carrot weevil
10. Armyworm
11. Cutworms

While the record on insect abundance was searched back to 1900, the period 1940 to 1973 was given greatest attention, since it was during this period that the new insecticides came into general use and also during this period that the use of aldrin, dieldrin and heptachlor was replaced by other soil insecticides.

CONCLUSIONS

1. Soil insects are a continuous problem to agriculture in Ontario. The nature of infestations may be cyclic and unpredictable as is the case with armyworms, some species of cutworms or the seed-corn maggot, or an annual problem as is the case with the onion and cabbage maggots.
2. Several species of insects, e.g., carrot rust fly, cabbage maggot, onion maggot, seed-corn maggot, cutworms, had developed resistance to aldrin and dieldrin prior to the banning of these compounds in Ontario, in 1969. In fact, use of these materials reached a peak in 1961 and declined thereafter.
3. The concentration of onion and carrot growing in a few areas in Ontario has accentuated the problems with carrot rust fly and onion maggot.
4. There is no evidence that populations of the armyworm, cabbage maggot, carrot rust fly, carrot weevil, northern corn rootworm, onion maggot, or seed-corn maggot, have changed substantially during the past thirty years or that damage from these insects has become any more severe. In tobacco the seed-corn maggot has been less abundant during the past 10 years than it was during the preceding 10 year period.
5. There is evidence that populations of white grubs and wireworms have declined in recent years.
6. There is evidence that populations of cutworms and flea beetles have increased during the past few years.
7. Strong research emphasis has been placed on the problem of soil insect control in Ontario for the past 20 years. Thus, effective insecticides have been developed and registered for use as replacements for the organochlorine insecticides, e.g. chlorpyrifos and leptophos for cutworm control and numerous other effective materials such as carbofuran, fensulfothion, fonfos, phorate, etc. for other species of soil insects. Where there is evidence that some species of soil insects are on the increase, e.g. cutworms and flea beetles, active research projects are already underway to find more effective methods of control.

8. In the past recommendations developed for soil insect control in Ontario usually had application elsewhere in Canada. This is no longer the case. For example, in Ontario only one species of cutworm is a problem in tobacco. It was controlled with short residual materials such as chlorpyrifos and leptophos. In Quebec where 5 species of cutworms with different life cycles attack tobacco the short residual materials are not persistent enough to control all species.

SPECIFIC SOIL INSECTS

A) CABBAGE MAGGOT *Hylemya brassicae* (Bouché)

The cabbage maggot has been reported in the Annual Report (Proceedings) of the Entomological Society of Ontario nearly every year since 1900. It has been a major factor in the production of all cole crops. Some reports during this period are as follows:

1910. L. Caesar. "These troublesome pests have been about as abundant as usual."

1915. Arthur Gibson. "The cabbage maggot was particularly destructive to cauliflowers, cabbages, turnips and radishes."

1920. H.F. Hudson. "I do not know when I can recall a season when so much damage was done to cabbage, cauliflower, radish and turnips by various root maggots."

1930. L. Caesar. "Less injury was done than in an average year."

1937. C.R. Twinn. "Quite severe damage from the cabbage maggot, *Hylemya brassicae*, was reported in eastern and southern Ontario."

1947. C. Graham MacNay. "Root maggots were not plentiful in Ontario."

1957. C. Graham MacNay. "The population and damage was considerable in Ontario with egg laying being three and one-half times the average of the previous ten years."

1958. C. Graham MacNay. "In Ontario spring damage to cruciferous transplants and to early turnips was extensive, some early turnips being ploughed under."

1965. H.W. Goble. "Root maggots, mostly *Hylemya brassicae* Bouché on cole crops were very abundant in May and June."

1968. H.W. Goble. "The cabbage maggot, *Hylemya brassicae*, was a problem in several areas where correct and adequate control was not applied."

1972. H.W. Goble. "The cabbage maggot was a problem in several areas on early cabbage, cauliflower and turnips where correct and adequate control was not applied."

Summary

1900 to 1952. The injury from this insect on all cole crops was severe in years of high populations. Some of these were 1915, 1920 and 1937. There was no very satisfactory control during this period. In 1915, tarred felt paper discs were placed around transplanted cole crops. By 1917, corrosive sublimate (mercuric chloride) or cheese cloth covering over the plants were added as possible control measures with corrosive sublimate along with calomel (mercurous chloride) being the principal treatment up to 1952.

1953 to 1962. The amount of damage varied during this period but growers had a more effective control and loss was restricted to certain farms. The mercury treatments were replaced by chlordane at first and then by aldrin, dieldrin or heptachlor.

1963 to 1966. The aldrin-resistant strain of the cabbage maggot developed in several areas of Ontario and was especially noticeable on rutabagas. Large acreages were rendered unmarketable as DDT and diazinon failed to give control on rutabagas. The damage on other cole crops was kept at a low level by diazinon and azinphosmethyl. Resistance to control by aldrin developed several years before its use was banned.

1967 to 1973. The growers of stem brassica continued to obtain satisfactory control with organophosphorous insecticides. By 1967, rutabaga growers obtained control with fensulfothion, chlorfenvinphos or carbofuran.

Conclusion

The cabbage maggot population has not increased. Crop loss has been and will continue to be severe without an adequate control program.

B) ONION MAGGOT *Hylemya antiqua* Mgn.

The onion maggot is an important insect in Ontario. It would appear it may not have been so important prior to 1937, since during that period onion production was not concentrated in a few places. A few reports from the Annual Report (Proceedings) of the Entomological Society of Ontario are as follows:

1913. Arthur Gibson. "Onion and cabbage maggots were rather plentiful."

1915. L. Caesar. "It is worth recording that in the great onion marshes of Kent County I could scarcely find a root maggot (onion maggot) when visiting the district this summer."

1920. L. Caesar and W.A. Ross. "Here and there throughout the province this insect caused considerable loss."

1929. L. Caesar and W.A. Ross. "Some fields were heavily damaged but, in general, the damage wasn't severe."

1937. C.R. Twinn. "Infestations of the onion maggot, *H. antiqua* Mgn. were about average in all provinces except Ontario where a great increase was noted; loss in some fields was 50 per cent of the crop and, in a few, up to 80 per cent."

1941. C.R. Twinn. "Local severe damage to onions by the onion maggot, *H. antiqua* Meig., was reported in Ontario."

1947. C. Graham MacNay. "With the exception of Quebec, where damage was considerable, only light infestations were reported throughout the Dominion."

1949. C. Graham MacNay. "Damage to onions was severe in 1949, and general from the southern interior of British Columbia eastward to Prince Edward Island."

1957. C. Graham MacNay. "In Ontario, damage ranged from moderate to severe where control materials were not applied." The control from 1949 to 1957 had been first by chlordane then aldrin.

1958. C. Graham MacNay. "In western Ontario the most severe outbreak on record developed and persisted to the end of the season. Losses ranged to 100 per cent in some plantings." This was the first of the cyclodiene-resistant strain of the onion maggot.

1958 to 1973. The organophosphorous insecticides used mostly as granular in the seed furrow have prevented serious loss. The populations varied from time to time but at no time was the injury serious.

Summary

1900 to 1937. The onion maggot was reported in the Annual Report of the Entomological Society of Ontario almost every year of this period showing that it was of considerable economic importance. There was no effective control during this period. Bethune, 1917, recommended a heavy whitewash of lime over the rows as soon as the plants started to appear through the soil. In 1937 an outbreak occurred with 50 to 80 per cent of some fields being destroyed.

1940 to 1949. Infestations and damage fluctuated from year to year with heavy damage again in 1949. The control recommended during this period was (a) lubricating oil emulsion over the row as a repellent or (b) calomel seed treatment.

1950 to 1957. Infestations fluctuated from farm to farm depending on the control used. However, where the recommended control was followed, this insect was well controlled. Chlordane, aldrin and heptachlor were used as soil treatments.

1958. A strain of onion maggot resistant to control by the cyclodiene insecticides had developed in most onion growing areas. Aldrin was the most widely used insecticide as a soil treatment. It was an "outbreak" year with very severe damage.

1959 to 1973. The use of organophosphorous insecticides such as diazinon, ethion and VC 13 in the seed furrow followed by other organophosphorous insecticides as foliage sprays prevented serious injury. There has been no serious loss during this period.

Conclusion

General population levels of this insect have not increased in the past 20 years. The infestation is general in onion producing areas and protection must be provided to prevent extensive loss.

C) SEED-CORN MAGGOT *Hylemya platura* (Meigen)

The seed-corn maggot was reported in most years of the Annual Report (Proceedings) of the Entomological Society of Ontario from 1900 to 1937. However, during this period it was seldom reported as a major pest. This may, in part, be the result of some crops, such as corn, being grown mostly for fodder and thus was not sown so early in the spring. Some reports are:

1916. L. Caesar. "The corn seed maggot nearly destroyed some fields of beans in Prince Edward County."

1920. H.F. Hudson. "This is the first time that I have seen any injury by this pest in western Ontario."

1930. C.R. Twinn. "Corn and beans have suffered considerable loss in southwestern Ontario from attacks of the seed-corn maggot."

1947. C. Graham MacNay. "Root maggots (*H. cruciferae*) were not prevalent in Ontario."

1952. C. Graham MacNay. "Scarcely any damage occurred on beans in southwestern Ontario, where infestation was the lightest ever recorded."

1953. C. Graham MacNay. "Infestation in southwestern Ontario was the most severe on record."

1955. C. Graham MacNay. "As usual in southwestern Ontario, the seed-corn maggot was a serious pest in field beans and, to a lesser extent, on soybeans."

1959. C. Graham MacNay. "The widespread use of seed dressings in the province prevented major losses in beans, corn, peas and cucurbits."

1958 to 1961. Seed-corn maggot caused serious damage to young tobacco transplants.

1960 to 1973. The seed-corn maggot was referred to only in the 1960 and 1964 reports and these reported minor damage.

Summary

1900 to 1929. Seed-corn maggot populations varied from year to year but, in general, the damage was not severe. There was little available in a direct control during this period except to sow shallow in a well prepared seed bed. If the plants were destroyed, it was recommended to reseed at once.

1930 to 1951. The population varied from year to year but, generally, was not large. There was considerable injury in 1930 and 1937. No specific control.

1952 to 1955. Little injury in 1952 but damage was serious from 1953 to 1955. Lindane and aldrin seed treatment was available at this time but was not generally used. The damage was considerable.

1956 to 1973. The damage was light except in a few fields, with the exception of tobacco (1958 to 1961). Maggots became resistant to aldrin. A diazinon planting water treatment was effective. Most susceptible seeds such as corn, beans, peas, etc., were treated with a seed dressing of aldrin, dieldrin or lindane with lindane being the principal material from 1968 to 1973.

The seed-corn maggot has continued to be of considerable importance in establishing early crops of corn, beans, peas and cucurbits since 1900. The loss has been greatly reduced with seed dressings and planting water treatments since 1956 to the present time.

Conclusion

No change in population in most situations. The populations in tobacco seem somewhat less during the past 10 years than during the 10 years preceding.

D) CARROT RUST FLY *Psila rosae* (Fabricius)

The carrot rust fly was first reported in the Annual Report (Proceedings) of the Entomological Society of Ontario in 1941, although it had been reported in Ontario before this. The population increased from 1941 to 1947 when "In Ontario, late carrots suffered major damage - 150,000 bushels unmarketable in one area alone" (MacNay 1947). In 1948 the injury was less severe and varied from farm to farm but damage was extensive again in 1951 and 1952. In 1954 severe flooding of Bradford Marsh, the principal carrot producing area, reduced the population greatly and heavy infestations did not become re-established until 1958. The use of aldrin or chlordane prevented loss except on a few farms in the period 1959-1964. By 1964 the aldrin-resistant strain had developed (Niemczyk 1964)[1)].

Following 1964 various less effective control measures were used with no reports of serious injury recorded for some time. In 1969 Agriculture Canada, under Dr. A.B. Stevenson, commenced a new research program on this insect at Bradford Marsh.

The following report is by private communication from Dr. A.B. Stevenson, Research Station, Agriculture Canada, Vineland Station, Ontario.

The per cent injury and/or population in any one plot does not give a reliable figure for the Marsh as the infestation varied greatly from farm to farm. Injurious populations were probably more widespread in 1971 and 1972 than from 1969 to 1970. There was a very large adult emergence in the spring of 1973 yet, in general, injurious populations were less frequent than in the preceding two years and population counts in the check plots of the research plots were down. This was attributed to higher heat units in the summer of 1973. The carrot rust fly is adapted to cool temperatures.

Summary

1946. The carrot rust fly was reported as causing economic loss in Ontario.

1947. The carrot growers suffered major damage to the extent of 150,000 bushels of unmarketable carrots.

1948. The damage to commercial crops varied from farm to farm but was less severe than in 1947. Populations in home gardens decreased greatly. There was no specific control except late planting for the principal crop.

1949 to 1952. Chlordane was used on a few farms on early carrots. The injury from the carrot rust fly varied during this period with heavy damage in 1951 and 1952.

1953. Aldrin and chlordane were recommended. Damage was reduced.

1954. Flooding of the Marsh reduced the population greatly and, with the cyclodiene insecticides, damage was not severe for a number of years.

1964. The aldrin-resistant strain had developed on some farms.

1965 to 1973. The loss was not severe during this period with diazinon used for the resistant strain in 1965 followed by other organophosphorous insecticides.

1969. Aldrin, chlordane and heptachlor were banned but they were ineffective two years before this.

1973. Carbofuran or organophosphorous insecticide sprays were used.

Conclusion

This insect appears to be cyclic with no trend to greater or less importance. It seems evident that this insect would destroy a great deal of the carrot crop except for a satisfactory control.

References

1) Niemczyk, H.D. 1964. Contact toxicity of 10 insecticides to adults of the carrot rust fly. Pesticide Research Report, National Committee on Pesticide Use in Agriculture, Ottawa, Canada, p. 95.

E) NORTHERN CORN ROOTWORM *Diabiotica longicornis* (Say)

This insect is of economic importance only in southwestern Ontario in an area from York and Simcoe Counties to Windsor. This is, however, the principal corn-growing area.

This insect develops only in fields where corn is planted following corn the preceding year. This may explain why the northern corn rootworm was not reported in Ontario until 1941 when the practice of growing corn on the same field for a number of years was established. The following are reports from the Canadian (Agricultural) Insect Pest Review, Ottawa, Ontario.

1941. D.A. Arnot. "Adults of the corn rootworm, *Diabiotic longicornis*, have eaten the silks from tips of ears in a field near Chatham, Ontario. The insect is present in other corn fields, but little damage has been noted. This is the first time the silk-eating habit of this insect has been noted in the vicinity."

1942 to 1959. Occasional mention of this insect as adults feeding on various plants.

1960. G.F. Manson. "Corn rootworm is on the increase in Essex County as a result of continuous corn cropping."

1965. C. Graham MacNay. "Infestation by the northern corn rootworm continued to increase in southwestern Ontario. Severe damage and lodging was evident in many fields, especially Essex and Kent Counties, where corn had been planted on the same land for several consecutive years."

1968. Isobel S. Creelman. "Many fields of continuous corn showed severe injury by *Diabiotica longicornis* in Lambton and west Middlesex Counties, Ontario."

1970 to 1972. The following are reports from the Proceedings of the Entomological Society of Ontario (H.W. Goble):

1970. "The northern corn rootworm caused some damage in southwestern Ontario."

1972. "The northern corn rootworm caused damage in some fields in southwestern Ontario."

In 1956 DDT was recommended to control adult beetles on various plants. Aldrin and heptachlor were recommended as a band treatment to

corn at planting time during the years 1958 to 1964. The organophosphorous insecticides phorate and diazinon were added in 1965 but aldrin was the most widely used treatment until it was restricted in 1967. Since 1967, chlordane has been included in the recommendations for control along with several organophosphorous insecticides and since 1971, carbofuran.

Summary

1900 to 1941. There is no report of this insect in the Annual Report (Proceedings) of the Entomological Society of Ontario or the Canadian Insect Pest Review.

1942 to 1960. There is no report of root-feeding damage during this period although it is likely there was, as aldrin and heptachlor was recommended by 1958.

1961 to 1967. There were reports of a great increase in this insect. Concern about the cyclodienes was noted in 1966 and some organophosphorous insecticides were recommended as alternatives.

1968 to 1972. There was no report of heavy loss from the northern corn rootworm. There is no report of infestations east of York County despite the fact that a large acreage of 'continuous corn' is grown in that region.

Conclusion

Populations of the northern corn rootworm have not increased during the past 10 years. Insecticide treatments are widely used.

F) WHITE GRUBS *Phyllophaga* spp.

The damage from various species has been severe at times, particularly in the second year of their three-year cycle. The following are examples of statements recorded in the Annual Report (Proceedings) of the Entomological Society of Ontario. A note on these important pests appeared in 36 of these Reports between 1900-1937. Examples quoted from a few Reports are:

1919. H.F. Hudson. "The white grub, the immature form of the May or June beetle, is one of the most important and most injurious of soil-infesting insects and one of the hardest to control."

1945. G.H. Hammond. "This was an 'outbreak' year. "Throughout this infestation, damage to arable and non-arable pasture and meadow was very pronounced at many points, representing the loss of thousands of acres of sod."

The Reports for 1948, 1951, 1954, and 1957 were similar, the years of the second-year larvae of the June beetles. The situation changed drastically in 1960 as the following quotation from the 1960 Report shows:

1960. C. Graham MacNay. "In southwestern Ontario, contrary to expectation, white grubs were less injurious than in any corresponding period of their three-year cycle for at least 12 years."

There has been no major "white grub year" in the last 16 years. White grubs have not been destructive enough to be reported in the Annual Report (Proceedings) of the Entomological Society of Ontario during this period.

Summary

1900 to 1949. There was no control for white grubs on agricultural land except rotation of crops, discing several times and other cultural methods. For golf greens and lawns the recommendation included the application of from 44 pounds in one application to as high as 645 pounds of lead arsenate per acre per season (Metcalf 1939).

1949 to 1957. Chlordane and lindane were used in limited areas in 1949 followed by aldrin, chlordane, dieldrin and heptachlor. White grubs were controlled on golf greens and lawns but up until 1957, there still was damage on pasture.

1958 to 1967. During this period all cyclodiene insecticides and lindane were available and recommended for white grub control except on pasture. There was no direct recommendation for pasture yet white grub damage was not important in 1960, 1963, or 1966, years when damage was expected on untreated land.

The cyclodiene, chlordane, has continued to prevent loss on lawns and turf. Since treatments were not applied, it is not known why white grub populations dropped to a low level from 1960 to 1973 on pasture land.

Conclusion

Populations of white grubs have decreased during the past 20 years.

G) WIREWORMS

Trends in wireworm populations are indicated in the Annual Report (Proceedings) of the Entomological Society of Ontario.

1909. C.J.S. Bethune. "Complaints of injury to the roots of many plants by the attack of wireworms have been received from various quarters, in fact never a year goes by without much loss from their predation."

1925. L. Caesar and W.A. Ross. "Seldom have we received so many complaints of wireworm injuries as this year."

1940 to 1943. C.R. Twinn. During this period wireworms were not reported in the Annual Report of the Entomological Society of Ontario or were reported as not being important.

1944. C.R. Twinn. Referring to southwestern Ontario, the Report stated: "the worst on record for the area."

1945 to 1953. C.R. Twinn and C. Graham MacNay. Damage was reported serious during most of this period.

1955. C. Graham MacNay. "In southwestern Ontario, wireworms caused very little damage as most susceptible crops were protected by chemical methods."

From 1956 to 1973 there is no report of serious injury to agricultural crops from wireworms. This is the result of effective chemical control, including soil treatment with cyclodiene insecticides such as aldrin, dieldrin and heptachlor up to 1967 and mainly lindane as a seed treatment with some chlordane soil treatment to 1973.

Summary

1900 to 1954. Wireworms caused considerable injury to agricultural crops from 1900 to 1954. There was no specific control for wireworms up to this time as shown by the following reference by Alan Dustan: "There is no specific control known for these pests, although growers (potato) may do much to lessen their destructiveness by proper farming methods." (Ritchie, Dustan 1936[2]). Wireworms were not listed in the Ontario Department of Agriculture protection calendars until 1954, when various cyclodienes were recommended.

[2] Ritchie, T.F. and Alan G. Dustan. 1936. The potato in Canada. Dom. of Can., Dept. Agri. Pub. 483: 47-48

1954 to 1973. From 1954 to 1973 cyclodiene insecticides controlled wireworms either as a seed or soil treatment. There is no report of serious injury during this period for Ontario as shown in the Proceedings of the Entomological Society of Ontario and the Pesticide Report of the National Committee on Pesticide Use in Agriculture. Aldrin, dieldrin and heptachlor were banned in 1967 but lindane as a seed treatment and chlordane continued to give satisfactory control.

Conclusion

Populations have declined.

H) FLEA BEETLES

There are large numbers of species of flea beetles. Those referred to here are either *Phyllotreta* spp. or *Epitrix* spp. With many of the flea beetles the important injury is from the adults on the foliage. However, the larvae develop in the soil feeding on the roots and thus are included as soil-infesting insects. It is not usual for the potato flea beetle to be important in Ontario causing tuber injury. Some years there has been considerable root damage on rutabagas from the larvae of one of the flea beetles, probably the newer species, *Phyllotreta cruciferae*.

The following are from the Annual Report (Proceedings) of the Entomological Society of Ontario:

1910. Arthur Gibson. "The turnip flea beetle, *Phyllotreta vittata*, was noticed to be very abundant on young turnips and radishes, particularly the former, on May 28th."

1916. Arthur Gibson. "In the latter half of June this insect (potato flea beetle) was present in noticeable numbers."

1928. W. A. Ross and L. Caesar. "This species (turnip flea beetle) destroyed fields of young turnips in a few localities, thus necessitating replanting."

1932. L. Caesar and W. A. Ross. "This flea beetle (potato flea beetle) was very abundant on tomatoes, early potatoes and tobacco this spring."

1936. C. R. Twinn. Several species were reported as injurious in Ontario such as the potato flea beetle on potato, tomato and tobacco and the banded flea beetle on beets, beans and carrots. The turnip flea beetle was not abundant.

1945. C. R. Twinn. "Injurious numbers of the potato flea beetle occurred in potato-growing areas of the Dominion from Prince Edward Island to Manitoba."

1955. C. Graham MacNay. Mr. MacNay's report for Ontario is very general about several species referring especially to home gardens.

1965. H. W. Goble. "A newer species of flea beetle, *Phyllotreta cruciferae*, was present in extreme numbers in plantings of

rutabagas, rape and other cole crops. Flea beetle larval damage to roots of rutabagas rendered some fields unmarketable."

1968. H. W. Goble. "Flea beetles, *Phyllotreta* spp., caused some damage early in the season."

1973. F. L. McEwen. "Flea beetles (various species) were particularly abundant this year on cole crops, potatoes and tomatoes."

Summary

Flea beetles and their damage has been reported fairly regularly in the Annual Report (Proceedings) of the Entomological Society of Ontario since 1900. However, the Reports do not indicate they have been a major problem in the production of agricultural crops.

1900 to 1936. The potato and turnip (striped) flea beetles were the two most injurious species. No report indicated they greatly reduced the crop.

Control - Bordeaux mixture followed by barium fluosilicate.

1937 to 1964. Flea beetles of various species caused above ground damage. Usually the injury was not extensive although high populations occurred in 1936 and 1945.

Control - Barium fluosilicate followed by calcium arsenate and Bordeaux. Derris dust and other arsenicals were used mostly up to 1947 when DDT replaced the arsenicals.

1965 to 1968. Root damage from the larvae of *Phyllotreta cruciferae* was severe in several rutabaga-growing areas, especially Huron County. The loss was considerable. This type of root injury was present to a lesser extent in 1967 and 1968.

Control - Almost completely DDT against the adults.

1969 to 1973. The rutabaga root damage lessened. The potato flea beetle was extremely abundant during this period, the injury being to the foliage.

Control - DDT on rutabagas in 1969; then carbaryl, endosulfan, azinphos-methyl or carbofuran.

Conclusion

Flea beetle populations (at least of some species) have increased in recent years.

I) CARROT WEEVIL *Listronotus ongeonensis* (LeConte)

There is no report on the carrot weevil in the Annual Report (Proceedings) of the Entomological Society of Ontario from 1900 to 1956. Reports in later years indicate the following: In 1956, 150 acres were damaged in Bradford Marsh and in 1957, 300 acres. In 1958 the Report stated: "In Holland Marsh, damage to early carrots was less than in 1957." The Report for 1959 was: "Infestation in the Holland Marsh, Ontario, continued to spread and in 1959 losses in early carrots ranged as high as 70 per cent in part of the Marsh." In 1960 the loss was "confined to a small area". From 1964 to 1969 DDT as a spray was recommended against the carrot weevil in the Ontario Vegetable Protection Recommendations. This weevil was not mentioned in the Reports again until 1972 when the Report said it "increased slightly".

The following Report is by private communication from Dr. A.B. Stevenson, Research Station, Agriculture Canada, Vineland Station, Ontario.

The carrot weevil has spread to new farms and new areas in the Bradford Marsh since 1970. It has increased on farms where no insecticide program was used. However, except for infestations being slightly more widespread, there has been little change in the general infestation and damage.

Summary

1900 to 1956. No report.

1956 to 1959. The weevil caused some loss and spread more widely in the carrot growing areas. There was no recommended control.

1960 to 1963. The infestations decreased in some areas with no recommendations for control during this period.

1964 to 1969. DDT as a spray was recommended. No economic damage reported.

1970 to 1973. The carrot weevil spread more widely with an increase where carbofuran was not used as a control.

Conclusion

Populations have not increased. This is an insect where no direct control was recommended until 1964. Cyclodiene insecticides used on carrots for carrot rust fly control from 1949 to 1967 may have effected control. Adulticide sprays (parathion and diazinon) for carrot rust fly control used for many years also may have provided a degree of control.

J) ARMYWORM *Pseudaletia unipuncta* (Haworth)

The armyworm is more cyclic than most soil-infesting insects. The natural control factors at times are ineffective allowing an outbreak year.

The following are reports from the Annual Report (Proceedings) of the Entomological Society of Ontario.

1914. A. W. Baker. This was an "outbreak year". "The armyworm occurred particularly throughout the whole Province." The loss on grain alone was estimated at a quarter of a million dollars in Ontario.

1938. A. W. Baker. "Although the outbreak in 1938 was widespread throughout Ontario, there were probably not as many counties with moderate to heavy infestations as in 1914. On the other hand, the areas of severe infestation were larger and more numerous in 1938."

1950. C. Graham MacNay. "The armyworm occurred in outbreak numbers on winter wheat and to a lesser extent on corn along the north shore of Lake Erie in the Leamington-St. Thomas area of Ontario."

1954. C. Graham MacNay. "In Ontario the attack affected all areas where cereal crops are grown except the counties bordering on Lake Erie." This was a devasting outbreak.

1955. C. Graham MacNay. "There was damage in a small area of south-western Ontario. The large outbreak numbers of 1954 were controlled by natural factors in nearly all of the Province."

1964. H. W. Goble. "This was an outbreak year. The acreage treated to control the armyworm was 38,180 by air, 36,560 by ground sprayers and 4,260 by poison bran bait."

1965. H. W. Goble. "There were no reports of infestation from the armyworm in 1965."

1972. H. W. Goble. "There were localized attacks of the armyworm in Dufferin, the Niagara Peninsula and the Ottawa Valley."

1973. F. L. McEwen. "These insects were present in damaging numbers in a small area of Ontario."

Summary

There have been only four years since 1900 when the armyworm was in devasting numbers across Ontario. These were in 1914, 1938, 1954 and 1964, period of 24, 16 and 10 years apart. There has been no major outbreak in the last nine years.

Control of this insect in the 1914 and 1938 outbreaks consisted of applying a Paris green - bran bait. In the 1954 outbreak, the poison bran bait was again employed with either Paris green or DDT as the toxicant. In 1964 some bran bait was used but control consisted mainly of spraying with carbaryl and/or malathion.

There were minor, localized, injurious numbers in 1950, four years before the serious 1954 outbreak; a minor localized report of injury in 1955, a year after the 1954 devastation; and minor scattered infestations in 1972 and 1973, eight and nine years after the last major attack.

This makes it difficult to predict the next heavy infestation but nothing suggests any change from the last 73 years. There is no evidence that the population of the armyworm has changed. It is likely, however, that another "outbreak" will occur before long.

Conclusion

No change in population. An outbreak year is expected soon.

K) CUTWORMS

Cutworms will be considered as a group even though various species vary greatly both in number and economic importance.

Cutworms are recorded as causing damage in varying degrees to crops in 38 of the 39 Annual Reports of the Entomological Society of Ontario between 1900 and 1937. Some of the Reports are as follows:

1909. Arthur Gibson. "Cutworms were present, as usual, in injurious numbers."

1920. L. Caesar and W. A. Ross. "According to reports received from different parts of the province (Ont.), cutworms were usually destructive in May and June to tomatoes, corn and cabbage."

1929. L. Caesar and W. A. Ross. "Cutworms apparently were of no particular importance except in southwestern Ontario where they were more abundant and injurious."

1936. C. R. Twinn "In general, however, cutworms were less injurious than in 1935, particularly in eastern Ontario."

1950. C. Graham MacNay. "Several species, mainly the dark-sided cutworm, the black cutworm and *Feltia* sp. were present in outbreak numbers in many areas of Ontario.

1960. C. Graham MacNay. "In southwestern Ontario, various species of cutworms, mainly the black cutworm, required control measures to prevent serious damage in tobacco, sugar beets, onions, and various other crops."

1961 to 1966. The dark-sided cutworm became resistant to cyclodienes in 1961 and was present at outbreak levels until 1966. Effective control measures utilizing first DDT (1967) and now chlorpyrifos and leptophos have reduced the population to a low level.

Cutworms were not reported in the 1966 to 1968 Annual Reports, indicating serious damage had not taken place. In 1969, the black cutworm caused considerable damage to rutabagas in Huron County. In 1970 several species caused extensive damage on vegetables.

1971. M. W. Goble. "Cutworm damage was not as severe as in 1970."

1972. H. W. Goble. "Cutworm damage was, generally, not severe but several species cause some crop loss."

Summary

Cutworm populations and their injury has fluctuated widely. 1900 to 1952. Cutworm populations and their damage was considerable in what was termed "outbreak years" such as 1950. The control used during this period was hand application of a bran-Paris green bait, when required.

1953. DDT as a heavy soil treatment was recommended as an alternative to the bran-Paris green bait.

1954 to 1960. The bran-poison bait was recommended but soil treatment with aldrin and DDT and by 1958 also heptachlor were more generally used. During this period cutworms were well controlled.

1961 to 1966. Resistance to control by aldrin developed in tobacco growing areas. DDT was recommended as an alternative as a poison bait. Control was poor. The black cutworm caused loss on rutabagas.

1967 to 1971. Several species of subterranean cutworms caused damage on tobacco and vegetables. DDT was removed from the recommendations. Chlorpyrifos and leptophos were used on tobacco. Carbaryl remained for other crops.

1972 to 1973. Cutworms, especially subterranean species, continued to be a problem. Carbaryl continued as the recommendation for most species with chlorpyrifos and leptophos used on tobacco and on some vegetables.

Conclusion

Cutworms have been a problem in crop production, especially on tobacco, many vegetables, corn and other crops for years. It would appear that subterranean species have increased in importance the last few years.

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